

Assignment 3 – Simple Shell with Pipes

Description:

This task required the development of a basic shell in C capable of receiving and executing user-entered commands. The shell receives user input, parses it into distinct commands, and executes them utilizing the `fork()` and `execvp()` system calls. The shell allows piping, enabling the output of one command to serve as input for another. The shell displays the process ID (PID) of each child process along with its exit status.

Approach:

My approach to implementing the shell was as follows:

1. **Reading User Input**
 - Used `fgets()` to read user input from standard input (stdin).
 - Handled end-of-file (EOF) conditions (CTRL+D or file redirection).
 - Removed newline characters to properly format commands.
2. **Parsing Input into Commands**
 - Tokenized the input string using `strtok()` to handle multiple commands.
 - Stored parsed commands into an array, allowing for execution.
3. **Executing Commands**
 - Created a child process using `fork()`.
 - Used `execvp()` to execute the command within the child process.
 - Used `waitpid()` in the parent process to wait for child execution and print exit status.
4. **Handling Piping**
 - Identified commands separated by `|` and created pipes accordingly.
 - Used `dup2()` to redirect standard input (stdin) and standard output (stdout) for proper piping.
 - Ensured multiple piped commands execute correctly.
5. **Error Handling**
 - Printed error messages for invalid commands or execution failures.
 - Ensured invalid commands did not crash the shell.

Issues and Resolutions:

Issue 1: Handling EOF and Input Redirection

- **Problem:** When testing with `make run < commands.txt`, the shell did not exit after processing the file.
- **Cause:** `fgets()` was not handling EOF correctly, causing an infinite loop.
- **Resolution:** Added a check for `fgets()` returning NULL to exit the shell gracefully.

Issue 2: Implementing Piping Correctly

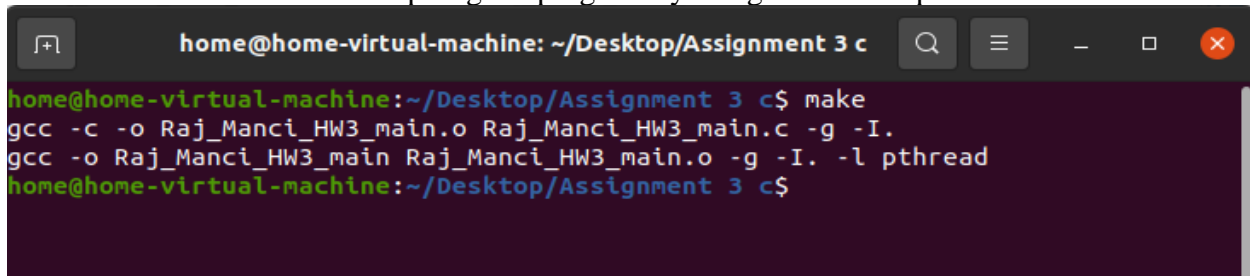
- **Problem:** Initially, the shell could execute simple commands but failed when processing piped commands like `ls | wc -l`.
- **Cause:** The pipe setup was incorrect; `dup2()` was not correctly redirecting input/output across processes.
- **Resolution:** Carefully implemented pipe creation and redirection, ensuring each child process handled stdin and stdout correctly using `dup2()`.

Issue 3: Handling Invalid Commands

- **Problem:** If a user entered an invalid command (foo_bar), the shell crashed instead of printing an error.
- **Cause:** The shell did not handle `execvp()` failures properly.
- **Resolution:** Added an error check for `execvp()`, printing an error message and exiting the child process with an error code.

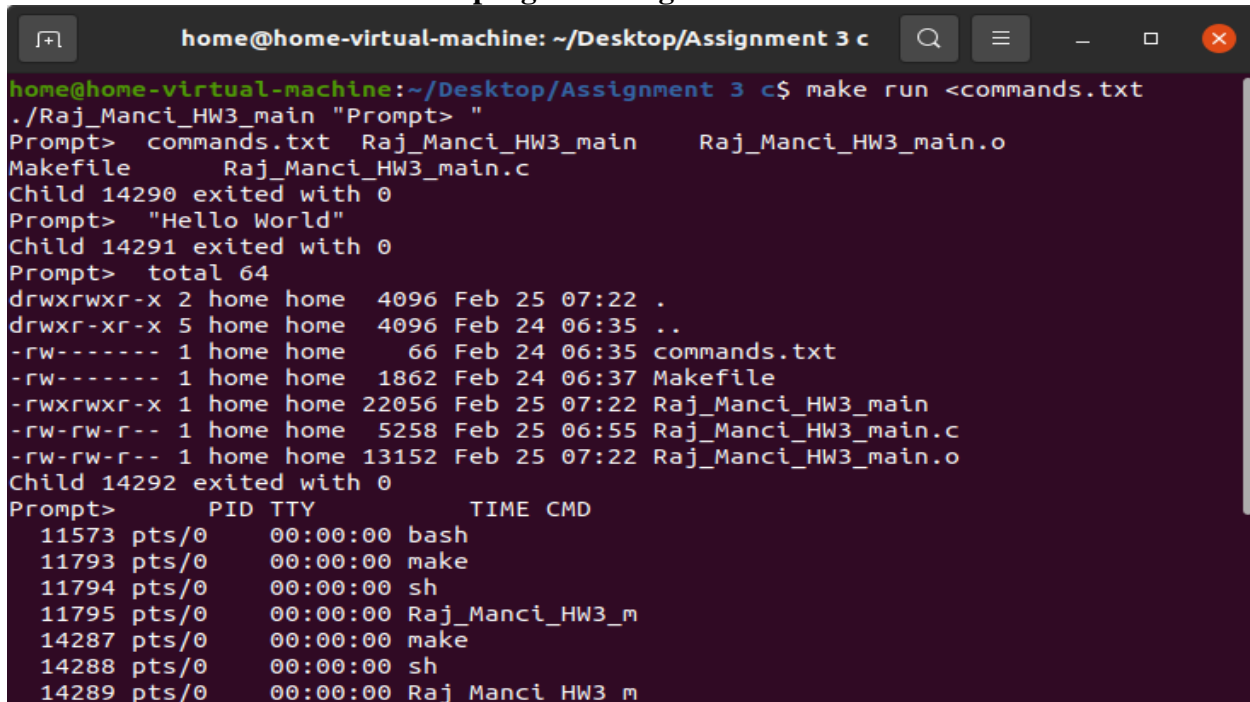
Analysis:

Below is the screenshot of compiling the program by using make as required.

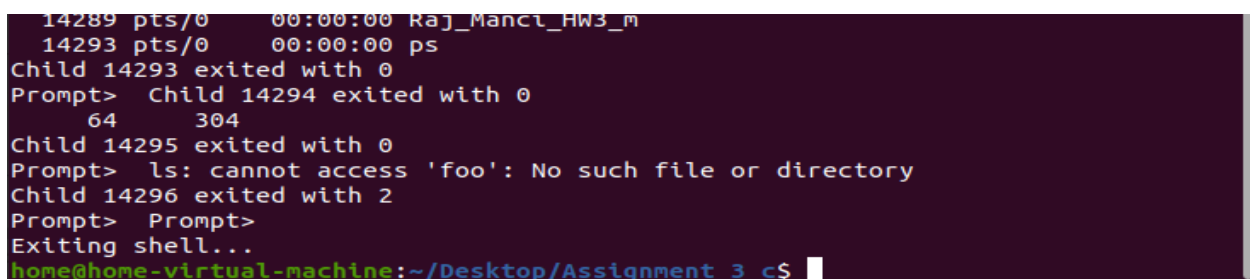


```
home@home-virtual-machine: ~/Desktop/Assignment 3 c
home@home-virtual-machine:~/Desktop/Assignment 3 c$ make
gcc -c -o Raj_Manci_HW3_main.o Raj_Manci_HW3_main.c -g -I.
gcc -o Raj_Manci_HW3_main Raj_Manci_HW3_main.o -g -I. -l pthread
home@home-virtual-machine:~/Desktop/Assignment 3 c$
```

Screenshot of the execution of the program using the Provided Command.txt File:



```
home@home-virtual-machine: ~/Desktop/Assignment 3 c
home@home-virtual-machine:~/Desktop/Assignment 3 c$ make run <commands.txt
./Raj_Manci_HW3_main "Prompt> "
Prompt> commands.txt Raj_Manci_HW3_main Raj_Manci_HW3_main.o
Makefile Raj_Manci_HW3_main.c
Child 14290 exited with 0
Prompt> "Hello World"
Child 14291 exited with 0
Prompt> total 64
drwxrwxr-x 2 home home 4096 Feb 25 07:22 .
drwxr-xr-x 5 home home 4096 Feb 24 06:35 ..
-rw-r--r-- 1 home home 66 Feb 24 06:35 commands.txt
-rw-r--r-- 1 home home 1862 Feb 24 06:37 Makefile
-rwxrwxr-x 1 home home 22056 Feb 25 07:22 Raj_Manci_HW3_main
-rw-rw-r-- 1 home home 5258 Feb 25 06:55 Raj_Manci_HW3_main.c
-rw-rw-r-- 1 home home 13152 Feb 25 07:22 Raj_Manci_HW3_main.o
Child 14292 exited with 0
Prompt>
PID TTY TIME CMD
11573 pts/0 00:00:00 bash
11793 pts/0 00:00:00 make
11794 pts/0 00:00:00 sh
11795 pts/0 00:00:00 Raj_Manci_HW3_m
14287 pts/0 00:00:00 make
14288 pts/0 00:00:00 sh
14289 pts/0 00:00:00 Raj_Manci_HW3_m
```



```
14289 pts/0 00:00:00 Raj_Manci_HW3_m
14293 pts/0 00:00:00 ps
Child 14293 exited with 0
Prompt> Child 14294 exited with 0
64 304
Child 14295 exited with 0
Prompt> ls: cannot access 'foo': No such file or directory
Child 14296 exited with 2
Prompt> Prompt>
Exiting shell...
home@home-virtual-machine:~/Desktop/Assignment 3 c$
```